Attorney Docket No. 2316.1424US01

BULKHEAD ADAPTER WITH OPTICAL FIBER FOR SIGNAL ATTENUATION

Field of the Invention

The present invention relates generally to fiber optic bulkhead adapters. In particular, the present invention relates to bulkhead adapters incorporating optical fiber to provide signal attenuation.

Background of the Invention

Adapters for optically connecting optical fiber cables are known. Often, these adapters mount in bulkheads and allow an optical fiber cable on one side of the bulkhead to be optically connected with an optical fiber cable on the other side of the bulkhead. An example bulkhead adapter for holding two mating connectors is shown in U.S. Patent No. 5,317,663. In-line attenuators for attenuating signals transmitted by optical fiber cables are also known. Improvements to these known bulkhead adapters and in-line attenuators are desirable.

Summary of the Invention

The present invention relates to bulkhead adapters for optically connecting two fiber optic cables and providing a degree of attenuation of the signals passing between the cables through the use of optical fiber as the attenuation mechanism within the adapter. The attenuation fiber is held by an attenuation hub within the adapter with sleeves mounted at either end of the attenuation hub. The sleeves receive ferrules of optical fiber connectors holding the ends of the optical fiber. The attenuation hub provides an optical connection and attenuation of optical signals between the two cables.

A method of assembling an adapter in accordance with the present invention includes providing an attenuation hub with an optical fiber inside and placing a sleeve

over each of the ends of the attenuation hub. The method further includes placing the attenuation hub within a main housing of the adapter through an access opening and placing a cover over the access opening, whereby the attenuation hub is held within the housing.

An assembly in accordance with the present invention includes a fiber optic bulkhead adapter with an attenuation hub within the adapter, the hub holding optical fiber, and a fiber optic cable including a connector with a ferrule holding an end of the optical fiber. The adapter holds the attenuation hub and the connector ferrule such that the optical fibers are in optical contact.

A method of using a fiber optic bulkhead adapter is provided where the adapter includes an attenuation hub containing an optical fiber. The method includes inserting the adapter through an opening in a bulkhead and inserting a connector attached to an optical fiber cable into the adapter so the optical fiber of the cable is in optical contact with the optical fiber of the attenuation hub.

A variety of advantages of the invention will be set forth in part in the description that follows, and in part will be apparent from the description, or may be learned by practicing the invention. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention as claimed.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of the description, illustrate several aspects of the invention and together with the description, serve to explain the principles of the invention. A brief description of the drawings is as follows:

FIG. 1 is a perspective view of a fiber optic bulkhead adapter in accordance with the present invention.

FIG. 2 is an exploded perspective view of the fiber optic bulkhead adapter of FIG. 1.

FIG. 3 is an end view of the fiber optic bulkhead adapter of FIG. 1.

FIG. 4 is a cross-sectional view of the fiber optic bulkhead adapter of FIG. 1, taken along line 4-4 of FIG. 3.

FIG. 5 is an enlarged cross-sectional view of a portion of the fiber optic bulkhead adapter of FIG. 4.

FIG. 5A is the fiber optic bulkhead adapter of FIG. 5 with the fiber optic path including two segments of optical fiber.

FIG. 5B is the fiber optic bulkhead adapter of FIG. 5 with an airgap in the fiber optic path.

FIG. 5C is the fiber optic bulkhead adapter of FIG. 5 with a filter in the fiber optic path.

FIG. 6 is a perspective view of a fiber optic cable and connector for use with the fiber optic bulkhead adapter of FIG. 1.

FIG. 7 is an exploded perspective view of a bulkhead for receiving adapters according to the present invention with three adapters in position to be inserted through openings in the bulkhead.

FIG. 8 is a perspective view of the bulkhead of FIG. 7 with three adapters inserted.

Detailed Description

Reference will now be made in detail to exemplary aspects of the present invention which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

A fiber optic adapter serves to optically connect two segments of optical fiber. As shown in FIGS. 1 and 2, adapter 10 contains a main housing 12 and an access plate or cover 14. In the preferred embodiment of one type of adapter (SC type), the main housing 12 includes an axial cavity, defined by a top side-wall 16, a bottom side-wall 18, a right side-wall 20, and a left side-wall 22. The axial cavity of the main housing 12 extends between a first opening 24 and a second opening 26. Each opening 24 and 26 is sized to receive a fiber optic connector. Located in bottom side-wall 18 is a keyway 92

sized and shaped to receive a corresponding key of an optical fiber connector shown in FIG. 6 and discussed below.

Located on the exterior of the main housing 12 are tabs 28 and 30. Tab 30 is located on right side-wall 20 and tab 28 is located on left side-wall 22. The tabs 28 and 30 are operative in supporting the adapter 10 on a planar surface such as a bulkhead. In the illustrated embodiments, screws or similar fasteners may be used to connect the adapter to a bulkhead, as shown in FIGS. 7 and 8, and described below. Alternatively, clips or snap fasteners, rivets, or other removable or non-removable fastening means may be used to attach adapter 10 to a bulkhead. Recesses 38 are provided in housing 12 and cover 14 to permit the use of alternative fastener means such as a flexible clip shown and described in U.S. Patent No. 5,317,663, the disclosure of which is incorporated by reference. Angled retainers, such as those shown and described in U.S. Patent Nos. 5,214,735 and 4,995,688, the disclosures of which are incorporated herein by reference, can be used with the flexible clips of U.S. Patent No. 5,317,663. The angled retainer clips fit around the adapter and mount the adapter to a bulkhead at an angle to the face of the bulkhead.

Located on top side-wall 16 is an access opening 40. Access opening 40 allows inner housing assembly 41 to be inserted into the axial cavity of main housing 12 and also allows main housing 12 to be constructed by injection molding. Located on the interior of main housing 12 are ridges 54, extending longitudinally within the axial cavity along the interior corners of the axial cavity. The interior end of ridges 54 form opposing ends 55. Inner walls 56 in the axial cavity of main housing 12 and inner walls 58 on the inside of cover 14 engage ends 55.

Inner housing assembly 41 includes inner housing portions or halves 42 and 44. Inner housing halves 42 and 44 are identical in the illustrated embodiment. Each inner housing half may be constructed of plastic by an injection molding process. It is anticipated that other materials and other processes may be used for the construction of the inner housing. Each half includes a central cylinder 46 at one end, and a face 48 at an opposite end. Located intermediate along the length of cylinder 46 is ledge 50. Between ledge 50 and face 48 is a body 52. Ledge 50 is generally rectangular in shape.

Two halves 42 and 44 are assembled with their respective faces 48 contiguous so that cylinders 46 of each housing half combine to define a common cylinder. The distance between the two ledges 50 is equal to that of the distance between walls 56 inside main housing 12 and between walls 58 along cover 14. Extending from each ledge 50 of the inner housing halves 42 and 44 are a pair of retaining clips 60 and 62. Each retaining clip extends away from each ledge parallel to cylinder 46. In body 52 of each inner housing half is defined a sleeve opening 82 and an attenuation hub opening 78, the opening 78 having a larger diameter than opening 82. The transition between opening 82 and opening 78 forms annular ledge 80. It is anticipated that an alternative inner housing 41 may not include intermediate hub 76 and opening 78, so that sleeve opening 82 will extend the full length of each inner housing half.

Cylinders 46 of inner housing halves 42 and 44 are preferably coaxial in main housing 12 and define a common cylinder for optical alignment of two connectors. Located in the common cylinder are two sleeves 64 generally cylindrical in shape. In the illustrated embodiment, sleeves 64 include a split, or slot 66 running the length of the sleeve. Alternatively, sleeves 64 may not include splits 66. Located between sleeves 64 is an attenuation hub 68. Attenuation hub 68 includes two ferrule ends 70, each ferrule end 70 having a contact face 74. A length of optical fiber 72 extends through attenuation hub 68 between the contact faces 74. Optical fiber 72 provides a degree of signal attenuation for optical signals. Ferrule ends 70 are sized and shaped to be inserted into sleeves 64. Between ferrule contact faces 74 around ferrule ends 70 is defined a wider intermediate hub 76. The level of attenuation provided by the illustrated embodiment of adapter 10 is determined by the level of attenuation per unit of length of optical fiber 72, since optical fiber 72 extends continuously between contact faces 74.

One manner of assembling an adapter 10 begins with the individual components as shown in FIG. 2. One of the sleeves 64 is placed into sleeve opening 82 of inner housing half 44, through opening 78. Sleeve 64 is prevented from passing entirely through opening 82 by ridge 84. One of the ferrule ends 70 is inserted into the sleeve 64 in inner housing half 44 until one end of intermediate ferrule 76 rests against annular

ledge 80. A second sleeve 64 is placed on the ferrule end 70 extending from inner housing half 44 until it rests against intermediate ferrule 76 and the inner housing half 42 is placed over the inner housing half 42 so that sleeve 64 extends into opening 82. Inner housing half 42 is positioned so that faces 48 of both inner housing halves rest against each other and retaining clips 60 and 62 of each inner housing half extend parallel to each other, forming inner housing assembly 41. Inner housing assembly 41 is placed into the axial cavity of main housing 12 through opening 40 in top side-wall 16. Inner assembly 41 is positioned so that ledge 50 engages the opposing sides of inner wall 56 and retaining clips 60 and 62 are adjacent and parallel to left side-wall 22 and right side-wall 20. Cover 14 is then placed over opening 40 so that inner walls 58 engage the opposing ridge ends 55 of main housing 12 and ledges 50 of the assembled inner housing halves.

FIGS. 4 and 5 show a cross-sectional view of an assembled adapter 10 mounted to a bulkhead 120, as shown in FIG. 8. Opening 86 extends through attenuation hub 68 and receives optical fiber 72. As shown in the illustrated example, attenuation hub 68 includes two ferrule ends 70 with intermediate hub or sleeve 76 positioned about the junction of the two halves. Ferrule ends 70 are joined along ferrule inner faces 96. Opening 86 widens into opening 94 in inner face 96. This enlarged opening 94 allows for easier insertion of optical fiber 72 into opening 86 during assembly of attenuation hub 68. To assemble attenuation hub 68, a first end of fiber 72 is inserted into a first ferrule end 70 through opening 94 and into opening 86, then through opening 86 beyond face 74 of the first ferrule end 70. The second end of fiber 72 is inserted similarly through opening 96 into opening 86 of a second ferrule end 70 and then through opening 86 beyond face 74 of the second ferrule end 70. Ferrule ends 70 are joined along their respective faces 96 and placed within an intermediate ferrule 76. Fiber 72 is cleaved at each face 74 and polished.

FIGS. 5A through 5C show alternative embodiments for providing attenuation for fiber optic adapter 10. FIG. 5A shows optical fiber segments 72A and 72B defining an optical path through attenuation hub 68. Fibers 72A and 72B include inner ends 73 which are fused together physically and optically. These fibers may be fused slightly

offset to provide a degree of attenuation of the optical fiber signals transmitted through adapter 10. FIG. 5B shows optical fiber segments 72A and 72B defining an optical path through attenuation hub 68. Fibers 72A and 72B include inner ends 73 which are not physically touching but which are optically connected. Airgap 75 is defined between inner ends 73. Fiber optic signals transmitted through adapter 10 must pass through airgap 75, which provides a degree of attenuation of the signals. FIG. 5C shows optical fiber segments 72A and 72B defining an optical path through attenuation hub 68. Fibers 72A and 72B include inner ends 73 which are not physically touching but which are optically connected. Between inner ends 73 is filter 77. Fiber optic signals transmitted through adapter 10 must pass through filter 77 which attenuates the signal.

FIG. 6 shows a fiber optic cable connector 100 mounted to the end of an optical fiber cable 102. Cable 102 is any variety of known cable including jacketed fiber optic cable. Connector 100 includes an optical fiber 104 which is held at the end by ferrule 106, the end of optical fiber 104 located on contact face 105. Ferrule 106 is held by housing 108 including a first inner portion 114, and an axially slidable outer portion 116. Housing 108 defines two slots 110 on opposite sides of housing 108, and a key 112 orthogonal to the sides containing slots 110 used to mount connector 100 to adapter 10. Key 112 engages keyway 92 in housing 12 to properly position connector 100 through first opening 24 within the axial cavity of adapter 10. When properly positioned within the axial cavity of adapter 10, ferrule 106 engages a sleeve 64 of attenuation hub 68. When a first connector 100 is fully inserted into adapter 10, contact face 105 is in physical contact with contact face 74, and optical fiber 104 is in optical contact with optical fiber 72. When fully inserted, openings 110 in outer portion 116 engage clips arms 60 and 62 to releasably hold connector 100 within the axial cavity of adapter 10. When a second connector 100 is inserted into opening 26 of adapter 10, an optical connection is formed between the optical fiber of the first connector 100 and the optical fiber 104 of the second connector 100 through optical fiber 72 within attenuation hub 68.

Referring now to FIGS. 7 and 8, bulkhead 120 for mounting adapters 10 is shown. As shown, bulkhead 120 includes three openings 122 for receiving adapters 10

and openings 124 adjacent to each opening 122 for receiving fasteners such as screws 126. Screws 126 are inserted through openings 29 and engage openings 124 to releasably attach adapters 10 to bulkhead 120. FIGS. 7 and 8 show bulkhead 120 with three openings 122 for receiving three adapters 10. Alternative bulkheads may have more or fewer openings for receiving adapters, depending on the number of cables to be connected.

The illustrated embodiment shows an SC connector and an adapter for receiving an SC adapter. U.S. Patent No. 5,317,663 also shows an SC connector with a mating adapter for holding the connector. It is anticipated that the present invention can be utilized with other sizes and designs of connectors and appropriate adapters. FIGS. 10 through 16 of U.S. Patent No. 5,883,995 show one alternative optical fiber adapter and a mating connector which may be adapted to utilize the principles of the present invention.

Having described preferred aspects and embodiments of the present invention, modifications and equivalents of the disclosed concepts may readily occur to one skilled in the art. However, it is intended that such modifications and equivalents be included within the scope of the claims which are appended hereto.